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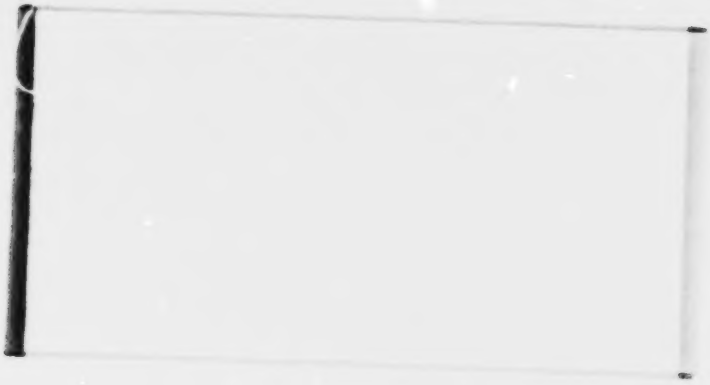

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ORGANIC RESEARCH SECTION
1985 ANNUAL REPORT

Report No. 86-109-K

R.W. Glass
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Organic Research Section
Chemical Research Department

ABSTRACT

This report reviews the major activities and accomplishments of the Organic Research Section in 1985 and outlines the 1986 work program.

job	file	date	report no.
740632-500-000	830.4	May 7, 1986	86-109-K

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EXECUTIVE SUMMARY

ORGANIC RESEARCH SECTION
1985 ANNUAL REPORT

R.W. Glass
Organic Research Section
Chemical Research Department

The Organic Research Section works primarily in the area of material science and technology as applied to non-metallic materials and reactor waste management. Most of the Section's work in the area of non-metallics (eg plastics, petroleum products, coatings etc) was done in support of the nuclear generation program (51%). Our major efforts in reactor waste management (17% of the budget) were in the areas of waste characterization and tritiated waste conditioning in support of Design and Development Division's Reactor Waste Management Program. Approximately 61% of the Section's work was supported by other Divisions and external contracts resulting in only a limited amount of discretionary research. In 1985 the amount of research work done increased to 37% of the total effort at the expense of reduced consulting and short-term "trouble shooting" activities. In 1986, 65% of the Section's support will be from other Divisions and external contracts. The discretionary OM&A funds will be limited and directed towards developing our capabilities to handle work more efficiently by increasing the level of automation, developing materials databases, further development of specific expert system applications and developing our capabilities in the area of quantitative, on-site, material performance evaluation techniques.

job	file	date	report no.
740632-500-000	830.4	May 7, 1986	86-109-K

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To Mr. F. J. Kee
Director of Research

ORGANIC RESEARCH SECTION
1985 ANNUAL REPORT

1.0 INTRODUCTION

This report reviews the major activities and accomplishments of the Organic Research Section in 1985 and outlines the 1986 work program. It is intended as an overview of the Section's activities. More detailed information on projects of interest may be obtained by contacting the Program Leader involved (see Figure 1) or from the reports listed in Appendix IV.

The Section is involved with studies in two main areas: non-metallic materials and nuclear waste. The area of non-metallics (plastics, petroleum products, sealants, coatings, composite materials etc) includes work directed towards the development, characterization, application, performance and processing of non-metallics with particular emphasis on decreasing the operation and maintenance costs and addressing safety issues in the nuclear generation program. Smaller efforts address dielectrics used in transmission and distribution systems and the decontamination of PCB-contaminated materials.

In the nuclear waste program, most of the current effort is on the characterization and conditioning of low and medium level reactor wastes for storage and disposal as well as defining the performance of the conditioned waste in a disposal environment.

Studies in both of these areas vary from long term research to short term "trouble-shooting", consulting and testing activities (see Figure 2). In 1985, approximately 55% of our work was funded by other Divisions (mostly in the Design and Construction, and Production Branches) while external contracts amounted to about 6% (see Figure 2). OM&A funds supported the balance of our work. These funds are used to support our own research initiatives, develop new capabilities as well as co-fund client-funded work or external contracts. "Class 8" funds are for preparation of papers, conference attendance, technical committee activities and staff training and development and amount to about 5% of the total funds.

Figure 1 shows the operating structure of the Section together with the current assignments of personnel and major activities of each of the Programs.

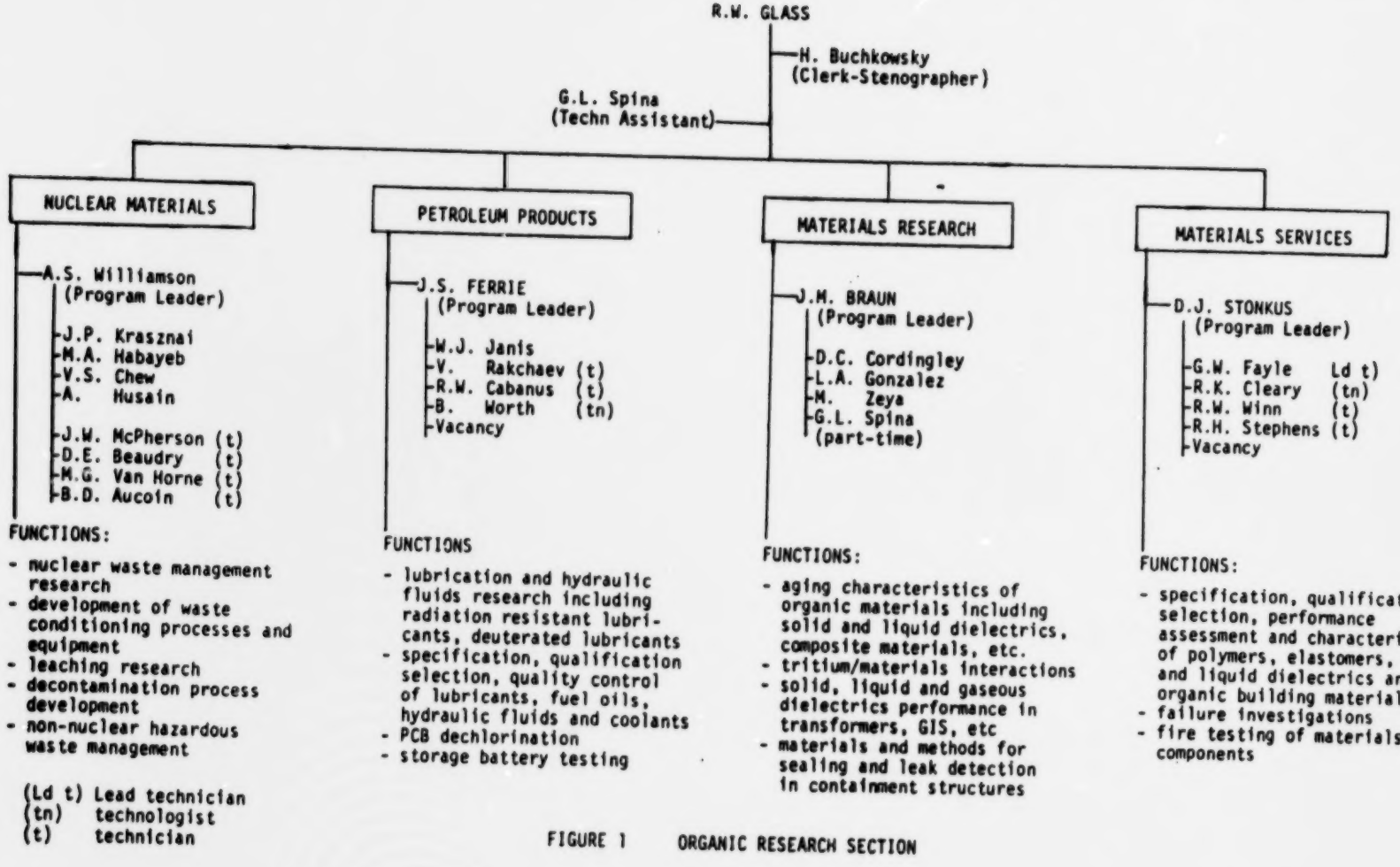

FIGURE 1 ORGANIC RESEARCH SECTION

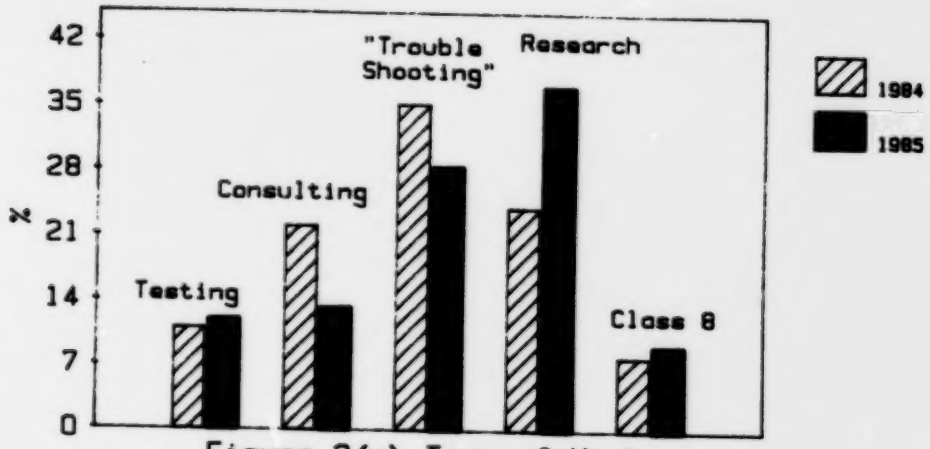

Figure 2(a) Type of Work

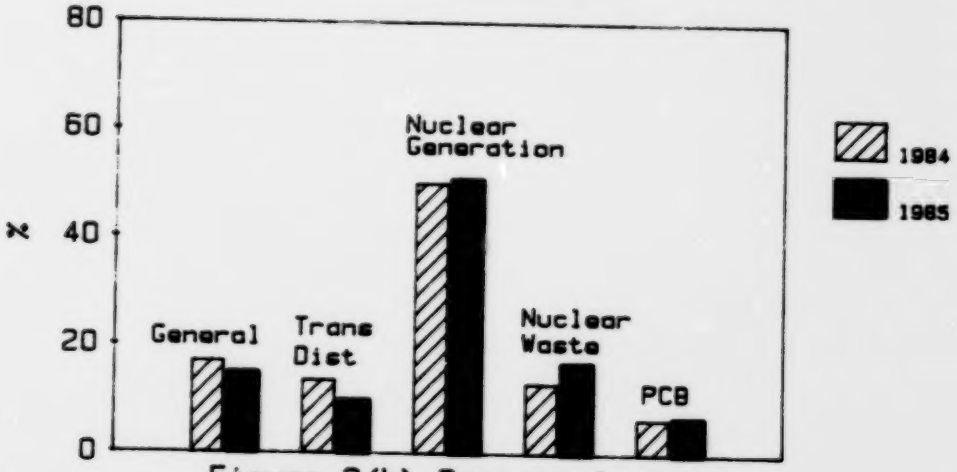

Figure 2(b) Program Areas

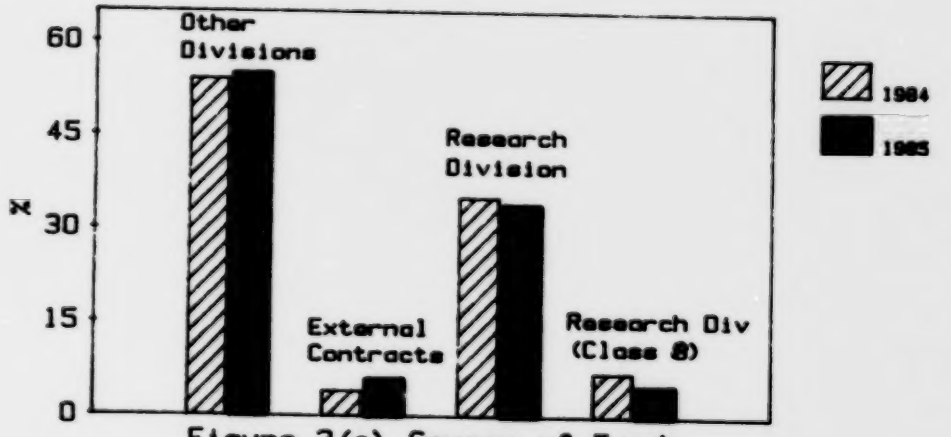

Figure 2(c) Source of Funds

FIGURE 2

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2.0 NUCLEAR GENERATION ($1,150k; 72% transfer, 28% OM&A)

2.0.1 Non-Metallic Materials ($730k)

2.0.1.1 Safety Systems

Bruce Vacuum Building Roof Seals: Aid was provided to repair the failed Bruce NGS 'B' vacuum building seal. A detailed study of the failed seal revealed that the failure was caused by the tension supports rather than material defect. Consultation was provided on methods of monitoring damaged areas of the Bruce NGS 'A' vacuum building seal that exhibited damage similar to the type that caused the failure at Bruce NGS 'B'.

Containment Leak Detection and Measurement: During 1985, studies continued on the development of test methods and equipment to measure leakage and identify leak sites from the containment envelope of the plant. Studies were undertaken to quantify the bubble response from standard-sized holes at various levels of pressure and leakage when sprayed with soap solution. A technique was also developed to capture and measure the leakage from a single leak site with a plastic film placed over the leak site and outfitted with a flow meter. An SF_6 tracer gas technique was evaluated, with encouraging results, during commissioning of Bruce Unit 7 and has revealed unexpected leak sites. It is expected these studies will be continued in 1986 with CANDEV funding.

Airlock Inflatable Seals: A laboratory facility has been designed to undertake an evaluation of the flex life and failure mode of inflatable seals on a full-size personnel air-lock door test rig. Seals can be subjected to repeated inflation/deflation cycles while leakage through the seal wall as well as across the seal face is monitored. The facility can be used to evaluate the performance of existing seals and/or prove new seal designs and materials. Components for the apparatus and seals for testing have been ordered and operation of the facility is expected to commence early in 1986, also with CANDEV support.

Calandria Elastomeric Seals: Calandria rubber seals at Pickering NGS 'A' were inspected and recommendations were made to repair the damaged area. Consultation and specification reviews were provided to the design of the calandria shield elastomeric seal for Darlington.

Cable/Electrical Component Qualification: Ongoing qualification of cables and electrical components were initiated for Pickering NGS 'A' and preliminary results show that materials have not been significantly degraded after 12 to 14 years of operation. Darlington NGS terminal boxes were qualified for nuclear application. A program evaluating woven wire grip supports for nuclear cables was completed and will offer substantial saving over the current support system. An investigation of failed Bruce NGS 'A' fuel handling control cables showed that the fault was not due to material degradation but rather to the cable design. Fire barriers for nuclear cable penetrations were assessed and recommendations made on methods of installation at Darlington. A survey of flammability of bus bar insulation systems was completed and reported.

Participation continued on CSA, IEC and IEEE committees preparing cable standards. Round robin tests were performed with CSA and IEC members to evaluate our test procedures. Ongoing qualifications of new materials and in-service electrical cables and components will continue in 1986.

Tritiated Heavy Water Transportation Package: The flammability of a urethane foam to be used in the package was investigated and found to be non-fire propagating even when exposed directly to a flame.

Vacuum Building Headers: A study on the aging of epoxy and fiberglass components under simulated vacuum building conditions was completed. The materials remained stable under these conditions but a significant drop in tensile bond strength of FRP bonded specimens was recorded.

Irradiated Fuel Rod Cask Seals: Permeation coefficients were determined for krypton, iodine and helium through Viton, the sealing material considered by NMMD for irradiated fuel rod casks. A special gas chromatographic technique was successfully used to make measurements over the range of 60 to 200^{o}C. Good agreement was obtained with literature values for the reference gas (helium).

Station Battery Performance: Sandia National Laboratory contracted Ontario Hydro to study the effects of simulated seismic events on the survivability and performance of naturally aged and artificially aged emergency power batteries. Formation of brittle, corroded, positive bus material was the most significant aging effect in terms of seismic survivability of naturally aged cells, with excessive positive plate sulphation also being of significance. New cells submitted to accelerated aging at 71^{o}C exhibited case and positive grid embrittlement, in addition to the aging effects observed with naturally aged cells. Embrittlement and/or cracking of positive buses was aided by corrosion along large grain boundaries and could be minimized by modifying casting procedures to reduce the quantity of large grained material allowed in the buses, or perhaps by developing corrosion inhibitors or protective coatings for buses. The cell testing program will continue in 1986.

2.0.1.2 Non-Safety Applications

Deuterated Lubricants: Most of the preliminary tests on samples of two deuterated lubricants and their undeuterated counterparts have been successfully completed. Although the density changes in the deuterated products have been as expected, one lubricant, a synthetic hydrocarbon has shown unexpected changes in viscosity and low temperature properties. The investigation of deuterated lubricants will continue in 1986 with emphases on lubrication and stability characteristics.

SLAR Program: Support was provided to the Spacer Location and Repositioning (SLAR) program by developing materials for the encapsulation of the devices. The encapsulation materials selected lend to casting air-free encapsulations with good dielectric strength properties. In addition, systems were established

for mechanically protecting and waterproofing the connecting wires. Eight prototype SLAR devices were prepared and submitted to AECL for evaluation. The encapsulation and wire sealing systems are performing without problems.

D_2O/Oil Demulsification: A small particle size active carbon designed for water purification was found effective for removing oil from downgraded heavy water containing a persistent oil emulsion which could not be handled by the existing clean-up train at Pickering NGS. Operating conditions for the preparation of a procedure for reclaiming 41,000 kg of heavy water were determined.

2.0.1.3 Consulting and Minor Jobs

Tests of most of approximately 300 lubricants and hydraulic fluids from a wide range of major equipment at nuclear generating stations indicated their suitability for further service. In addition, the causes of several serious field problems and a significant number of incipient problems identified thereby permitting corrective action to be taken. Potential problem areas noted included excessive sludging in hydraulic and thermal lubricating systems, poor corrosion preventative properties of lubricants in critical turbine lubricating systems and the identification of a previously unsuspected, but potentially dangerous low flash point contaminant in a combustion turbine lube oil.

2.0.2 Tritium ($130k)

An automated tritium permeation facility was built to study the transport and interactions of tritium with non-metallic materials. The facility consists of diffusion cells and a number of dedicated tritium detectors including a Pirani Gauge, a PC-5 Proportional Counter, a Varian 3400 Gas Chromatograph and a photomultiplier unit equipped with solid scintillant. A CYGNUS-25 Fourier Transform infrared spectrophotometer can be interfaced with the facility. Automated data acquisition control is achieved via a Taurus microprocessor unit. The facility has been designed to handle a broad range of materials and is not limited to elemental or oxidized tritium.

To assist safety analyses of the of the Tritiated Heavy Water Transport Package (THWTP), the permeation of tritiated heavy water vapour through the THWTP gasket material was determined to estimate the tritium loss. It was found that the activity of tritium in heavy water and the relative humidity of air have no effect on the diffusion parameters for the permeation of tritiated heavy water vapour through the gasket material.

Methods to remove tritium from epoxy - lined drums used to transport heavy water were investigated to allow for safe and economical disposal of the drums. Vacuum application proved only partially successful and additional experiments are planned.

The performance of solid scintillants used by the Health and Safety Division in a discriminating tritium monitor presently under development for CFFTP was reviewed. It was established that organic scintillators were best suited for the application. Surface treatment of the scintillators was successful in further controlling moisture condensation characteristics of the chilled scintillators.

Theoretical models were developed to describe interactions and migration of tritium (and other radionuclides) in non-metallic materials. The work examined a number of material configurations relevant to either TRF or nuclear plants. Leaching experiments were carried out to confirm the validity of the model calculations. Studies will continue in 1986 to characterize the material interactions; both FTIR and the permeation facility are now operational to carry out this work.

2.0.3 Decontamination/PHT System Studies ($290k)

Pitting/Oxide Characterization: Extensive studies were undertaken in 1985 to characterize corrosion, oxide formation and define conditions promoting pitting corrosion of components. The most extensive pitting was found on the PNGS unit 2 specimens exposed to the low pH reagent during the April 1984 CAN-DECON decontamination. The PNGS Unit 2 reactor inlet end fitting bodies were pitted and the oxide on the non-pitted reactor outlet end fitting body was partly spalled off suggesting pitting on the end fitting occurs after the overlying oxide is removed. Several pitted specimens were installed in the PNGS unit 4 autoclave to investigate whether these pits will propagate when exposed to normal operating conditions. These specimens will be examined at a later date on removal from the autoclave. Laboratory kettle tests showed that severe pitting on carbon steel occurred in a low pH run without Rodine 31A corrosion inhibitor. Rodine 31A greatly reduces the general corrosion on the polished carbon steel surfaces, and reduces but does not eliminate pitting corrosion or improve the effectiveness of the test reagent. The weight losses of 410 SS specimens depend mainly on the pH of the test reagent and are not significantly affected by Rodine 31A.

In preparation for the CAN-DECON decontamination at Bruce A the surface oxides on various Bruce heat transport system components such as steam generator tubes and boiler manway hinges were characterized. The oxide and Co-60 inventories on the heat transport system were estimated to determine ion exchange resin requirements and probable decontamination factors.

A two-step process is being studied for the decontamination of SS-410 fuel channel end fittings at Pickering and Bruce. The process consists of an oxidizing dilute alkaline permanganate treatment followed by the reducing CAN-DECON step. The effectiveness of the oxidizing treatment has been determined under a variety of conditions and the effects of process parameters quantified. The effectiveness of alternate oxidizing agents is being explored; this work will be completed in 1986.

The conditions under which ferrous oxalate precipitates during a CAN-DECON were studied theoretically. Solution of model equations has enabled the specification of solution conditions under which ferrous oxalate precipitation can be avoided. This work has been concluded and will be reported in early 1986.

Decontamination Support at PNGS and BNGS: Gamma spectrometry was used in the boiler room and reactor vault of PNGS Unit 3 to monitor the rates of field reduction during the Unit 3 decontamination in July. Similar support will be provided during the planned decontaminations of BNGS unit 1 and PNGS unit 4 in 1986.

In relation to these decontaminations, the following support studies will be carried out. Metal test specimens will be installed on the primary heat transport autoclaves to determine corrosion parameters as well as the changes in surface radioisotope concentration. Further heat transport system specimens from Bruce and Pickering reactors will be evaluated to determine the effects of decontaminations on system surfaces. In addition, a decontamination development project to study the oxide dissolution behaviour will begin in 1986.

System Monitoring: To assist in maintenance planning, the build-up of radioactive deposits on out-reactor surfaces was monitored by gamma spectrometry of various reactor components at PNGS and BNGS. This monitoring will continue in 1986.

A program has been initiated to relate gamma spectra at the outer surface of a pipe to internal radioisotope concentrations. This will provide information on radioisotope inventories on feeder pipes and possibly other components at PNGS and BNGS. The first phase of this work will be completed in 1986.

2.1 NUCLEAR WASTE ($410k; 56% transfer, 44% OM&A)

The major efforts in 1985 were in support of Design and Development Division's Reactor Waste Management Program in the areas of waste characterization and tritiated waste conditioning. These activities will be continued in 1986. Additional research in 1986 will concentrate on design of a site specific, integrated leaching test, development of organic liquid radioactive waste conditioning treatments and studies of advanced volume reduction technologies. Participation in the IAEA coordinated research program on an evaluation of low and intermediate level solidified radioactive waste forms and packages will allow us timely access to original research findings from the other research laboratories involved in the Agency program.

2.1.1 Reactor Waste Characterization

In 1985 the characterization of compactable solid radioactive waste for physical composition, beta-gamma activity levels, radionuclide inventory, tritium and carbon-14 contents, was completed. Approximately 70% by volume of the waste consists of paper and plastic with the remainder being a miscellany of other materials used at the stations such as rubber, fibreglass, vermiculite, etc. The waste is compacted into 0.5 m^3 bales, the beta-gamma activity of which was found to range between 1 to 7 mCi per bale. Most of this activity is contributed by radionuclides having a half-life of less than one year. Thus after storage for 10 years the beta-gamma activity will have decayed to 1.5 mCi for the most active bales due to cobalt-60 and cesium-137. Both tritium and carbon-14 were found in the waste at levels between 8-11 Ci and 1-6 μCi respectively per cubic metre of baled waste.

Similar characterization studies were commenced in late 1985 with respect to incinerable and non-processable wastes arising from normal operations and all three waste categories from the PNGS Units 1 and 2 retubing operation. This research will be completed towards the end of 1986. The data developed from this work will enable ready calculation of the radionuclide inventory of wastes being stored at the RWOS and assessment of their hazard in future disposal.

2.1.2 Tritiated Waste Conditioning

Waste handling requirements for managing tritiated waste expected to arise from the Darlington Tritium Removal Facility are under investigation. Work has shown that immobilizing the waste only prevents dispersal but is not sufficient to reduce daily tritium releases to 1×10^{-3}%. To meet this target, packaging the waste by either encapsulation or containerization must be relied on. The 1985 portion of the program focussed on:

(a) evaluating encapsulation and simple containerization of aqueous tritiated waste;
(b) identifying the tritium carrying species in tritiated vacuum pump oil; and
(c) measuring tritium releases from tritiated metallic components to determine whether further conditioning of this waste stream is necessary.

Containerization in high density polyethylene can meet the target release rate more easily and economically than encapsulation. The permeability constant of tritiated water through high density polyethylene has been measured which enables the required container thickness to be calculated to meet tritium release targets.

Vacuum pump oil is an effective sink for tritium gas and will therefore become tritiated on exposure to it. The major tritium carrying species however has been shown not to be volatile and is likely to be a mixture of high molecular weight hydrocarbons. Simple containment of the oil in polyethylene as for aqueous waste is expected to adequately retard tritum releases. This will be

confirmed in the 1986 portion of the research program. The tritium releases from metallic components leached in water have shown higher than expected release rates probably as a result of rapid isotopic exchange between the leachant water and the absorbed tritiated water present in the oxide layer of the metallic components. In the 1986 work program we will investigate the distribution of tritium in the metal and its oxide because if it can be shown that the tritium resides primarily in the oxide then descaling of the components may be an effective way of decontaminating tritiated metallic components.

2.1.3 Disposal Site Leaching Test

Leaching tests have often been criticized for not representing true waste disposal site conditions. To avoid this shortcoming we are attempting to develop a site specific leaching test. To develop such a test the effect of changing various parameters such as waste form size, leachant flow, leachant chemistry and leachant volume relative to waste form volume need to be determined.

So far we have investigated the effect of flow rate and waste form size on the releases of H-3 and C-14 from water extendible polyester resin waste forms. The results have shown that the tritium release rates are independent of flow rate. For C-14 however as the flow rate increases so does the C-14 release rate.

In 1986, C-14 releases from more complex cementitious waste forms will be studied in conjunction with various soils and backfill materials under controlled laboratory conditions. In parallel with this, large scale lysimeter tests are planned to be done at BNPD. This integrated leach testing program will be carried out in partnership with Civil Research (Dr. R. Dayal).

Another leaching study conducted in 1985 investigated variables such as volume of leachant-to-waste form ratio, static versus dynamic flow, leachant composition and nature of waste form, all of which have to be considered in the simulation of disposal conditions. Initially volume of leachant and nature of the waste (immobilized and untreated) were the most important variables. At later stages of leach testing, the nature of the test, static or dynamic, volume of leachant and nature of waste were found to be the dominant variables. The findings from this work will be used in 1986 in the design of the integrated leach test referred to earlier.

2.1.4 Radioactive Liquid Waste Management

An action plan for BNPD-Services Department is presently being developed by Nuclear Materials Management Department for the management of radioactive liquid wastes. Some of the more important waste streams have been identified. While some preliminary work on solidification of tritiated oil and wastes from the Freon-based dry cleaning facility has been completed, research in 1986 will address alternative conditioning processes and treatments such as incineration, decontamination and special packaging.

In 1985 construction and initial commissioning trials of the prototype, compact, waste solidification plant continued and satisfactory manual operation was achieved. The unit can handle decontamination solutions, ion exchange resin and other aqueous wastes. The equipment mixes a water extendible polymer with the aqueous waste stream to form an emulsion which chemically cures to a solid monolithic form. The maximum throughput of emulsion is 10 L/min which is equivalent to 6 L/min of waste feed. In 1986 it is intended to convert the apparatus to enable fully automatic operation. After achieving this goal, it is expected that an even more compact, portable system will be constructed.

2.1.5 Spent Resin Sampling

At the request of Nuclear Materials Management Department (NMMD), the Organic Research Section has undertaken to negotiate with Operations to obtain spent resin samples from Pickering and Bruce NGS moderator, heat transport and irradiated fuel bay purification systems. The resin samples will then be analyzed by the Water Research Unit for alpha, beta and gamma activity. This information is essential to allow us to:

(a) identify spent resin conditioning and packaging requirements for extended waste storage and disposal; and

(b) develop a realistic source term to model the transport of radionuclides from waste in a disposal facility through the environment to man,

Operations have agreed to provide samples over the next 18 months with assistance from Research. The sampling system will be demonstrated to Pickering and Bruce Operations on Research's test facility. Based on feedback from these groups, the system will, if necessary, be modified to avoid the spread of loose contamination and to ensure minimum radiation exposure to personnel in its vicinity. It is anticipated that the first resin sample will be available at Research by June 1986.

2.1.6 Irradiated Fuel Basket Decontamination

The second phase of a project directed at avoiding costly disposal of obsolete PNGS spent fuel storage baskets as radioactive waste was undertaken. A dilute aqueous solution of nitric and hydro-fluoric acids was found to effectively decontaminate (to release limits) the basket surfaces. This reagent is expected to undergo pilot scale testing in 1986.

2.1.7 IAEA Coordinated Research Program

An agreement has been signed with the IAEA to participate with other laboratories in an Agency coordinated research program on evaluation of low and intermediate level radioactive solidified waste forms and packages. In 1986 our input to this research program will concentrate on the evaluation of water

extendible polymer and cement immobilized decontamination wastes and ion exchange resins, and evaluations of matrices and packages for tritiated wastes.

2.2 TRANSMISSION AND DISTRIBUTION ($185k; 62%transfer 7% OM&A 31% EPRI/CEA)

2.2.1 Gas-Insulated Switchgear

Research into SF_6 insulated switchgear (GIS) performance was continued with EPRI and CEA support[6]. A comprehensive analysis of the moisture content of GIS has been carried out. Thermodynamic and transport equations have been used to develop a mathematical model to determine the water content of the different components of the GIS, exchanges with the atmosphere, and to predict dew points. Experimental data obtained from Norway was found to confirm the behaviour of water vapour in GIS as predicted by this model.

A draft patent application describing the use of an SF_6 byproduct detector (developed in collaboration with Electrical Research) for both fault location and partial discharge detection was submitted to the Canadian Patent Office. These studies will continue in 1986, focussing on the aging characteristics of epoxy spacers as part of a large, long term EPRI contract.

2.2.2 Transformers

A program to study the effects of exceeding transformer thermal overload limits on the service life of winding insulation was continued in 1985. Knowledge of the interaction between insulation moisture, system pressure, high voltage stresses and rate of winding temperature increase can help determine under what conditions power transformers might safely exceed their design ratings and assume a higher load profile. The first tests of conductor gassing under load using thermally upgraded paper to insulate a disk type transformer winding were carried out. Conductor hot spots resulting from a simulated short-term overload caused gassing of absorbed water. Increased pressure prevented or minimized this bubble formation due to water but is less effective in suppressing gasses formed by decomposition of the cellulose structure.

Studies on insulation paper and oil aging will continue in 1986 with the award of two CEA contracts on analysis of trace byproducts of overheated paper insulation and on the use of gas in oil analysis as an acceptance criterion for transformer loading above name plate rating.

2.2.3 Minor Jobs

A wide variety of small jobs were carried out to assess the condition of transformer oils and provide consulting assistance to field personnel.

2.3 ENVIRONMENTAL ($170k; 90% transfer, 10% OM&A)

2.3.1 PCB Mobile Processing Unit

The Mobile Processing Unit (MPU-1) for polychlorinated biphenyls (PCB) dechlorination in contaminated insulating oil was commissioned using approximately 22,000 L of PCB contaminated oil stocks. The MPU-1 was found capable of reducing the PCB content of 120-7000 mg PCB/kg oil to <2 mg/kg to produce an oil suitable for use in electrical equipment. The processing rate of the MPU-1 is approximately 6000 L per 8 hour day (four batches).

One day of processing yields approximately 100 L of an alkaline waste which closely matches the Ministry of Environment waste oil classification 251. Analysis indicates that neither oil nor waste contain significant amounts of severely toxic or hazardous compounds.

Acceptable operating conditions for service oils with about 200 mg/kg PCB content and 100 mg/kg chlorinated benzene content were determined to be: 110°C reaction temperature; 24 minute reaction time; and a 13.5/1 sodium to chlorine molar ratio. The addition of a small amount of water (about 175 mL/1500 L oil) was observed to aid the reaction by providing free hydrogen. A report on the commissioning tests was issued.

2.3.2 PCB Removal from Groundcover

Work was completed on a joint CEA/Ontario Hydro study to assess solvent extraction as a method to remove and concentrate PCB from contaminated soils and thereby reduce stocks of soils held as PCB wastes and provide an alternative to eventual incineration of such materials.

Pilot scale tests in a modified, sealed, concrete blender with a capacity of about 125 L showed that the solvent extraction process was as effective in removing PCB from soils on a large scale as in bench tests. Not unexpectedly, tests on lump clay internally contaminated with PCB confirmed that an extended contact period was required to obtain equilibrium conditions between PCB in the clay and solvent as compared to that for surface contaminated clay or topsoils. It was also evident from the extraction times required that size reduction of large soil lumps to a maximum particle size of 2-3 cm would enhance PCB removal. A CEA report (195 D 365) detailing the test results and presenting a conceptual design for a prototype extraction system was issued.

A solvent extraction procedure and a field method of determining the approximate concentration of low levels of PCBs in soils where leakage of PCB contaminated fluids may have occurred, were developed. Completion of this investigation is scheduled early in 1986.

2.3.3 Other PCB-Related Activities

A licensing agreement was negotiated and signed allowing a Canadian private company the non-exclusive rights to use the PCB dechlorination process in Canada. The first commercial use of the MPU-1 (leased to this company) will occur in 1986.

A member of the Section appeared several times as an Ontario Hydro witness at public hearings into the Regulatory Proposals for Mobile PCB Destruction Facilities to provide technical support for the Corporation's position concerning the use of the MPU-1 under the proposed regulations.

Technical support was also provided to other groups in Ontario Hydro involved with the preparation of the Environmental Assessment for the Low Level PCB Oil Treatment Process. A demonstration test of the MPU-1 performance will be conducted in February 1986 to gain "Technology Approval" for the process.

A PCB research program was prepared and presented to the PCB Management Committee. Emphasis was placed on the need for a consistent risk assessment approach throughout the Corporation and the development of techniques and processes to ensure the safe management of PCBs and PCB contaminated materials held in storage at approved sites throughout the Corporation.

2.4 UTILIZATION AND ALTERNATE ENERGY SYSTEMS ($40k; 75% OM&A 25% Rev)

2.4.1 Thermal Upgrading Effects on Wiring Components

A two year study of the effects of thermal insulation upgrading on the life of electrical insulation components is nearing completion. The objective of the work, supported by Energy, Mines and Resources and CEA, was to determine the existence of possibly hazardous conditions and/or reduction in component life. Temperatures under full load conditions were found not to exceed CSA ratings but certain electrical wire insulations performed unexpectedly poorly. Additional funds were obtained from CEA, in a separate contract, to investigate the aging characteristics of these wire insulations. This will be achieved by subjecting a representative sampling from several manufacturers to accelerated oven aging coupled with probing of the structural modifications by analytical techniques.

2.4.2 Hot Water Tanks -- Polyurethane Foam Insulation

An extensive review of the offgassing from polyurethane foam materials used in electric hot water tanks was carried out to determine the likelihood of noxious emissions during operations. Information was gathered from many sources including the CGSB, NRC, industry and the open literature. An experimental program is currently in preparation with support from Residential Marketing to

determine the nature of the products emitted and the loss of thermal resistance with time.

2.5 THERMAL AND HYDRAULIC GENERATION ($30k; 80% transfer, 20% OM&A)

A complete inspection of the major conveyor belts was carried out in July 1985 at Thunder Bay Terminals, a private materials handling facility for which Ontario Hydro must support certain capital expenditures. The belts exhibited deep cold weather cracks as well as severe ozone checking. Repair would not be cost effective and replacement was recommended with Goodyear Canada Inc SC 6700 as proposed by Thunder Bay Terminals.

A wide variety of small testing and consulting jobs were conducted on lubricant, hydraulic and other fluids for thermal and hydraulic generating stations. This work consisted of determining fluid properties, recommending appropriate petroleum products and identifying potential problems with equipment based on the sample properties submitted.

In 1986, we will start to do some preliminary work on the evaluation of the performance of organic and inorganic coatings for use in flue gas desulphurization equipment. Corrosion of components still remains a significant problem resulting in high maintenace costs and reduced availability of the system.

2.6 ELECTRIC POWER SYSTEMS ($10k)

As part of EPRI 2577-1, "Motor and Generator Insulation Life Estimation", a review was carried out on the status of ongoing research on generator condition monitors and related areas of research. The objective of the review was to identify those areas of work where significant advances could be made in the course of the project with particular emphasis on aging of generator insulation. Contacts were suggested and/or made with GE, Westinghouse, CEGB, NEI Parsons, Brighton Polytechnic and EDF. The possibilities for cooperative programs with other users were also outlined. The work program for 1986 will involve a study of commercially available sacrificial coatings to determine particulation behaviour, long term stability and ease of detection upon overheating. In addition the breakdown byproducts of overheated generation insulation materials will be investigated to determine the existence of unique, readily detected byproducts.

2.7 GENERAL RESEARCH PROGRAMS ($200k)

2.7.1 Minor Jobs for External Organizations

Laboratory assistance and advice was provided to technical personnel of several major oil refiners for tests such as air entrainment in cooperation with the

National Research Council Of Canada. A significant number of small test programs funded by outside organizations including major oil companies, electric utilities and electrical maintenace firms were conducted. These organizations do not have the expertise or capabilities to perform the tests carried out.

The fire test facility has been accredited by CSA to qualify fire retardant cable constructions and numerous tests have been performed for various manufacturers.

2.7.2 Resource Development

During 1985, a large number of staff developed their microcomputer skills with particular emphasis on spreadsheet, database and word processing applications. Skills were also developed in the use of new instrumentation acquired during the year eg. a multi-detector, multi-channel analyzer for field measurements of radioisotope concentrations and a gas chromatograph. In addition, the Department's new CYGNUS-25 Fourier Transform Infrared Spectrometer, with extensive spectral manipulation and searching capabilities, is now operational. The instrument is to be used by the Section in support of its long term research on non-metallic materials. Since the instrument's arrival, most of the effort has gone into becoming familiar with the machine's capabilities and training staff to operate it. Studies will be carried out on characterization of epoxy insulator surfaces, oxidation of polymers, products of SF_6 spacer degradation in the presence of electric discharge and interactions of tritium and tritiated water with non-metallics.

2.7.3 "Expert System" For Organic Coatings

Development of an expert system for specification of protective coating treatments for Ontario Hydro's maintenance and new construction requirements was started in 1985. This system uses sets of rules and variables to allow specific conditions and requirements to be analyzed and interpreted and the appropriate protective coating specification selected without the need for expert consultation. The program was developed in conjunction with Science Section using the EXSYS program and will run on an IBM PC microcomputer. Initial trials of the system were promising and it is hoped to bring it to a suitable operational level by mid-1986. Only minor modifications would be needed to make the expert system useful to any electric power utility.

2.7.4 Space Planning

Plans were developed for better integration of the Section's offices and laboratories (currently located in buildings KR, KD, KV, KE and KT) within the constraints of available space and money. In addition, we provided assistance to the design and specifications of equipment and instrumentation for the Division's new tritium laboratory. These activities are expected to decrease in 1986.

2.7.5 "Class 8" Activities

Section staff participated widely in the external scientific community activities. We presented and/or published papers, served in different capacities on a number of external research or standards committees as well as attending conferences and seminars. In addition, external agencies awarded approximately $300k of research contracts to Section staff during 1985.

Details of these activities, as well as a complete listing of reports issued in 1985, are given in Appendices I to IV.

3.0 OVERVIEW

1985 has seen a significant increase in the amount of research work done at the expense of some of the consulting and short-term investigations. This is in line with the long term strategy of the Section. During the year, initial steps were taken to increase the amount of equipment automation as well as increase the use of microcomputers within the Section. This has been successful with increased capabilities already evident. In addition, the first steps were taken towards "expert systems" to determine how appropriate they are for initial application to the large materials consulting role of the Section. Initial work on coatings highlighted the advantages and limitations of such systems and will be used as the basis for assessing its importance in other areas in 1986.

The reduced amount of OM&A funds available for 1986 has meant that the emphasis will be on building capabilities, new expertise, more efficient/effective ways of doing our work with little work done on discretionary research. Further emphasis will be placed on automation of equipment, development of materials databases for research and field applications, the application of non-destructive evaluation techniques to polymer matrices and development of expert systems.

We will be making further reductions in the amount of testing that is done, the exceptions being when we have unique facilities or expertise required by clients or external companies. Where it is possible, and our clients have the resources and are willing to do the work, we will train field staff to conduct that work maintaining close liason with them and auditing their work.

In summary, 1986 will be a period of building new capabilities and improved techniques for handling our work.

4.0 ACKNOWLEDGEMENT

The work of the Section has changed and is changing to better meet the current and future needs of the Corporation. All members of the Organic Research Section staff contributed to the successful implementation of these changes and made our work of even greater value to the Corporation. This has been achieved in spite of the pressures of meeting client's needs with the limited resources. Every member of staff has contributed to the achievements described in this report and those contributions are most gratefully acknowledged.

Approved by

O.A. Kupcis
Manager
Chemical Research Department

Prepared by

R.W. Glass
Supervising Chemist
Organic Research Section

APPENDIX I

External Contracts Continued from 1984

Title	Amount of Contract ($K)	Funding Agency	Project Manager	Status as of Dec 31/85
Standard Fire Test Method for Grouped Cables 249 G 389	56	CEA	D. Stonkus	Completed
Thermal Upgrading Effects on Electrical Wiring Components PO 56229	81	EMR/CEA	J.M. Braun	
Removal and Destruction of PCB from Contaminated Soils 195 D 365	60	CEA	J. Ferrie	Completed
Tritium Sorption of Coatings	25	CFFTP	A. Williamson	Completed
Thermal Endurance of Electrical Wiring 306 U 415	55	EMR/CEA	J.M. Braun	
Moisture in GIS 217 T 424	30	CEA	J.M. Braun/ F. Chu	
Leak Site Detection	40	CANDEV	D. Cordingley	Completed
SF6 Spacer Surfaces RP 1360-10	30	EPRI	J.M. Braun/ F. Chu	

CEA - Canadian Electrical Association
EMR - Energy, Mines & Resources
CANDEV - CANDU Development
EPRI - Electric Power Research Institute
CFFTP - Canadian Fusion Fuels Technology Project

APPENDIX I (continued)

External Contracts Awarded in 1985

Title	Amount of Contract ($K)	Funding Agency	Project Manager
Aging of NMD-7 Wire Insulation	70	CEA	J.M. Braun
Leak Site Detection	60	CANDEV	J.M. Braun
Chemical Analysis of Trace Products in Power Transformers	60	CEA	J.M. Braun
Gas in Oil Analysis in Transformer Overload Testing 206-T-507	110	CEA	J.M. Braun

APPENDIX II

COMMITTEE AND TASK GROUP MEMBERSHIPS

1. Internal

PCB Management Committee (R.W. Glass)

Standing Panel - Insulated Wire and Cable (D.J. Stonkus)

2. External

International Atomic Energy Agency, Consultant for a Technical Report, "Solidification of Organic Radioactive Waste" (A.S. Williamson)

International Atomic Energy Agency, Radioactive Waste Management Advisory Group (A.S. Williamson)

Commission of the European Communities, Low and Medium Level Waste Management Research Group (A.S. Williamson)

AECL/CSA/OH, Committee for Specification M286.46 on Aging of Elastomers in Nuclear Plants (D.C. Cordingley)

CSA C22.2 No 0.3: Test Methods for Electrical Wire Cables (D.J. Stonkus)

CSA C21.1: Committee on Control and Instrumentation Cable (D.J. Stonkus)

IEEE/ICC: Committee 12-32 Type Test Class 1E Nuclear Cable (D.J. Stonkus)

IEEE/ICC: Committee 12-36 Smoke, Toxicity & Corrosion Products of Cable Combustion (D.J. Stonkus)

IEC 15B, Working Group 2: Radiation (D.J. Stonkus)

IEC 20B, Working Group 12: Burning Characteristics of Electrical Cables (D.J. Stonkus)

IEC CSC.TC10: Committee on Fluids for Electrotechnical Applications (J.S. Ferrie)

APPENDIX III

PUBLICATIONS, PRESENTATIONS AND PATENTS

1. Papers Published

L.A. Gonzalez and M.V. Sefton, "Laboratory Evaluation of Stain-Length Passive Dosimeters for Monitoring of Vinyl Chloride and Ethylene Oxide", Am Ind Hyg, Assoc J 46(10):591-598 (1985).

M.A. Habayeb, "Leaching Performance of Cemented Decontamination Wastes", Nuclear and Chemical Waste Management, Vol 5, 351 (1985). M.A. Habayeb, "Carbon-14 Releases from Solidified IRN-150 Resin Wastes", Nuclear and Chemical Waste Management, Vol 5, 351 (1985).

2. Presentations

J.M. Braun and F.Y. Chu, "Novel Low-Cost SF_6 Arcing Byproduct Detectors for Field Use in Gas-Insulated Switchgear", IEEE Summer Power Meeting, Paper 85 SM 369-4, Vancouver, BC, July 1985.

F.Y. Chu, F. Lutz, J.M. Braun and H.A. Stuckless, "Effects of Power Arc Faults in Gas Insulated Substations", CIGRE Symposium "High Currents in Power Systems", Brussels, Belgium, June 1985.

J.M. Braun and A.S. Williamson, "Permeability of Protective Coatings to Tritium", ANS Topical Meeting on Tritium, Dayton, Ohio, April 30-May 2, 1985.

H. Stuckless, J.M. Braun and F.Y. Chu, "Degradation of Silica- Filled Epoxy Spacers by Arc Contaminated Gases in SF_6- Insulated Equipment", IEEE Winter Power Meeting, Paper 85 WM 163-1, New York, Feb 1985.

V.S. Chew and F.R. Greening, "The Effect of the CAN-DECON Decontamination Process on the Surface Oxides on Pickering Units 1 & 2 Feeder Pipes", presented at 6th Annual CNS Conference, Ottawa, Ontario, June 2-4, 1985.

M. Adam Habayeb, "Leaching Performance of Simulated Decontamination Wastes Solidified with Water Extendible Polyester Resin", Presented at the 6th Annual CNS Conference, Ottawa, Ontario, June 2-4, 1985.

A.S. Williamson, "Characterization of Low and Intermediate Level CANDU Reactor Wastes for Disposal", International Seminar on the Suitability of Radioactive Waste Products for Final Disposal, Kernforschungsanlage, Julich, Federal Republic of Germany, June 1985.

3. **Patents Awarded**

R. Filter and D.J. Stonkus, "Loadbreak Bushing & Snuffer/ Contact Assembly", Canadian Patent No 1,198,135; USA Patent No 4,516,823.

4. **Patent Applications**

J.M. Braun and F.Y. Chu, "SF_6 Decomposition Detector", Canadian Application No 490,129.

APPENDIX IV

REPORTS ISSUED IN 1985

NUCLEAR GENERATION

Non-Metallic Materials

D.C. Cordingley and G.W. Fayle, "Leakage Rate from Loca-Aged Inflatable Airlock Seals Pickering NGS 'B' Personnel Doors", Report No 84-282-K, File 835.6132, Jan 4, 1985.

D.C. Cordingley and G.W. Fayle, "Vacuum Building Roof Seal Inspection (Pickering NGS)", Report No 84-417-K, File 835.6211, Mar 25, 1985.

D.J. Stonkus, "Evaluation of a 15 kV Cable for Darlington NGS A", Report No 84-460-H, File 832.1, Jan 29, 1985.

D.C. Cordingley, "Assessment of Leakage and Release Performance of Sealing System and Release Latches for Blow-Out Panels on Interior Doors of Reactor Buildings, Pickering NGS", Report No 85-61-H, File 835.621, May 2, 1985.

L.A. Gonzalez, "Permeation of Iodine, Krypton and Helium Through Irradiated Fuel Rod Cask Sealing Material", Report No 85-335-H, File 835.611, Dec 24, 1985.

J.M. Braun, "Aging of Epoxy and Fiberglass Reinforced Plastic Components - Pickering NGS Dousing System", Report No 85-135-H, File 835.5, Jun 18, 1985.

D.J. Stonkus, "Air Tightness of Cable Fire Barriers", Report No 85-283-H, File 832.1011, Oct 18, 1985.

R. Strom, "D_2O/Oil Demulsification", Report No 85-111-H, File 836.35, Jun 11, 1985.

D.J. Stonkus, "A Study of Wire Woven Cable Support Grips", Report No 85-349-H, File 832.104, Dec 16, 1985.

W.J. Janis, "Seismic Testing of North Anna Nuclear Power Station Batteries - Cell Inspection and Capacity Tests", Report No C84- 107-P, File 832.31, Jan 4, 1985.

W.J. Janis, "Seismic Testing of Shippingport Nuclear Power Station Batteries - Cell Inspection and Capacity Tests", Report No C84-121-P, File 832.31, Jan 31, 1985.

V. Rakchaev, "Suniso 32 Compressor Lubricating Oil, Bruce Heavy Water Plant - Common Services Building", Report No C85-4-H, File 831.47, Jan 22, 1985.

R.K. Cleary, "Inspection of Pickering GS 'A' Irradiated Fuel Bay Liner", Report No C85-13-K, File 833.414, Mar 1, 1985.

W.J. Janis, "Seismic Testing of North Anna and Calvert Cliffs Nuclear Power Station Batteries - Second Stage - High Table Acceleration", Report No C85-19-P, File 823.31, X836.74, Mar 5, 1985.

D.C. Cordingley, "Thermal Testing of Witco Chemical Company Polyurethane Foam No 3475-8" Report No C85-23-H, File 837.82, Mar 7, 1985.

R.K. Cleary, "Roof Coating for Relay Room Unit 5 - Bruce GS B", Report No C85-39-K, File 835.35, May 29, 1985.

V. Rakchaev, "Phosphate Esters - Pickering NGS B", Report No C85- 50-H, File 836.504, Jun 24, 1985.

D.J. Stonkus, "Kinked Power Track Cables", Report No C85-51-K, File 832.105, Jun 19, 1985.

R.K. Cleary, "Boiler Emergency Cooling Water Storage Tank Liner - Unit 8 - Pickering", Report No C85-54-K, File 833.414, Jul 3, 1985.

R.K. Cleary, "Inspection of Mothballed A and D Plants", Report No C85-6l-H, File 833.226, Jul 19, 1985.

V. Rakchaev, "Phosphate Esters - Pickering NGS 'B'", Report No C85-62-H, File 836.504, Jul 18, 1985.

J.E. Lash, "Fire Test on Witco Chemical Company Polyurethane Foam No 3477-1", Report No C85-71-K, File 837.82, Sep 13, 1985.

R.W. Winn, "Evaluation of Rubber Materials for Use With Lead Acid Batteries", Report No C85-127-K, File 835.521, Dec 11, 1985.

R.W. Winn, "Inspection of Neoprene Calandria Support Sleeves in Unit 1 and Unit 2 at Pickering NGS", Report No C85-128-K, File 835.62, Dec 11, 1985.

R.W. Winn, "Examination of Valve Diaphragms from Pickering NGS", Report No C85-129-K, File 835.613, Dec 11, 1985.

Tritium

M. Zeya, "Permeability of Tritiated Heavy Water Transport Package Gasket Material to Tritiated Heavy Water Vapour", Report No 85- 19-K, File 835.611, May 28, 1985.

S.L. Vekris,J.M. Braun and S.H. Hawthorne, "Visit to Chalk River Tritium Laboratory - February 11, 1985", Report No C85-32-H, File 830.141, May 6, 1985.

J.M. Braun, "Solid Scintillants for Use in Discriminating Tritium Monitors", Report No C85-34-H, File 836.461, Jun 11, 1985.

M. Zeya, "Tritium Removal from Used Heavy Water Drums", Report No C85-67-H, File 837.812, Aug 26, 1985.

Decontamination

A. Husain, "Evaluation of a Two-Step Process for Decontaminating Pickering End Fittings", Report No 84-444-H, Mar 25, 1985.

V.S. Chew, "Oxide Characterization - Corrosion Coupons and Boiler Manway Hinges", Report No 85-23-H, File 836.29, Mar 29, 1985.

V.S. Chew, "Pitting Corrosion in Pickering Units 1 & 2", Report No 85-73-H, File 836.29, Jul 16, 1985.

S.L. Vekris, "The Separation of Ferrous Oxalate and Magnetite Particulate Mixtures", Report No C84-126-H, File 836.29, Feb 22, 1985.

S.L. Vekris, "Microsieving of Heat Transport Particulates - NPD NGS", Report No C85-18-K, File 836.3332-NPD, Apr 11, 1985.

V.S. Chew, "Preliminary Results on Oxide Characterization Pickering Units 1 & 2 End Fittings", Report No C85-35-H, File 836.29, Jul 10, 1985.

V.S. Chew, "Surface Activity on Douglas Specimens", Report No C85-40-K, File 836.3332-DOU, Jun 3, 1985.

V.S. Chew, "Pickering Units 7 & 8 Hot Conditioning - Analysis", Report No C85-46-K, File 836.332-PIC, Aug 1, 1985.

V.S. Chew, "Radioisotope Concentrations on Douglas Point Specimens", Report No C85-52-K, File 836.3332-DOU, Jun 30, 1985.

V.S. Chew, "Oxide Characterization - Specimens from Douglas Point", Report No C85-72-H, File 836.29, Oct 23, 1985.

A. Husain and D.E. Beaudry, "Gamma Spectrometry of Pickering NGS Unit 3

Components Before During and After the CAN-DECON Decontamination (July 28-31, 1985)", Report No C85-92-K, File 836.29, Nov 20, 1985.

V.S. Chew, "Evaluation of Corrosion Coupons - Pickering Unit 3 July 1985 CAN-DECON Decontamination", Report No C85-100-H, File 836.29, Nov 20, 1985.

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A. Husain, "Surface Characterization of Pickering NGS 'A' Spent Fuel Storage Basket", Report No 84-370-H, File 836.29, Jan 23, 1985.

M.A. Habayeb, "C-14 Releases from Simulated IRN-150 Moderator Resin Waste Forms", Report No 85-1-K, File 837.83, Apr 11, 1985.

A.S. Williamson, "Compactable Reactor Waste Characterization" Report No 85-58-K, File 837.812, Mar 27, 1985.

J.P. Krasznai, "Solidification of Liquid Waste from the Freon Base Dry Cleaning Process", Report No 85-180-K, File 837.83, Jul 25, 1985.

J.P. Krasznai, "Tritiated Waste Conditioning Part III (a) Performance of Containerized and Encapsulated Waste Forms", Report No 85-279-K, File 837.83, Nov 29, 1985.

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J.P. Krasznai and R.K. Cleary, "Shredding as a Means to Homogenize Solid Low Level Nuclear Waste", Report No C85-89-K, File 837.812, Oct 25, 1985.

J.P. Krasznai, "Visit to Brookhaven National Laboratories September 25 and 26, 1985", Report No C85-95-K, File 837.81, Oct 25, 1985.

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D.C. Cordingley, "Gasket Materials for Askarel Filled Equipment", Report No 85-109-H, File 835.6113, May 27, 1985.

R. Strom, "Insulating Fluids Research 1960-1984", Report No 85- 169-H, File 832.7, Jun 26, 1985.

R.H. Stephens, "Flammability and Oxygen Index Tests of Metalclad Switchgear Insulation", Report No C85-41-K, File 832.1011, May 29, 1985.

D.J. Stonkus, "Temperature Stability of Switchgear Bus Bar Insulation", Report No C85-90-H, File 832.1, Oct 2, 1985.

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THERMAL AND HYDRAULIC

J.M. Braun, "Thunder Bay Terminals - Assessment of Conveyor Belting", Report No 85-309-H, File 836.522, Oct 28, 1985.

V. Rakchaev, "Shell Extrema EPS Grease Ear Falls GS", Report No C85-28-H, File 831.34, Apr 4, 1985.

J.S. Ferrie, "Oil from Storage Tank - Lennox TGS", Report No C85- 57-H, File 823.76, Sep 9, 1985.

R.K. Cleary, "Maintenance Painting - Thunder Bay Terminals - 1985", Report No C85-87-K, File 833.221, Oct 2, 1985.

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V. Rakchaev, "Turbine Lubricating Oil from Unit 2 Nanticoke TGS", Report No C85-113-K, File 831.1-2A, Nov 21, 1985.

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J.M. Braun, "Status of Generator Condition Monitor Research in the UK and France - Trip Report", Report No C85-60-H, File 836.5111, Jul 9, 1985.

J.M. Braun, "Status of Generator Condition Monitor Research - R&D Opportunities", Report No C85-116-P, File 836.5111, Dec 5, 1985.

GENERAL

R.W. Glass, "Organic Research Section - 1984 Review and Programs", Report No 85-42-K, File 830.4, Feb 20, 1985.

V. Rakchaev, "Shell Corena 100 Compressor Oil", Report No C85-31- H, File 831.47, Apr 15, 1985.

V. Rakchaev, "Qualification Tests on Reformulated Gulf ISO 32 and 46 Steam Turbine Lubricating Oils", Report No C85-36-P, File 832.711, Apr 24, 1985

V. Rakchaev, "Reformulated Gulf ISO 32 and 46 Steam Turbine Lubricating Oil", Report No C85-75-H, File 831.311, Sep 17, 1985.

R.H. Stephens, "Evaluation of Oxide Inhibitor for Electrical Cables", Report No C85-77-H, File 833.227, Sep 3, 1985.

V. Rakchaev, "Transformer Deposit Hamilton Stirton TS", Report No C85-107-K, File 832.772, Nov 14, 1985.

EXTERNAL CONTRACT AND CFFTP REPORTS

CFFTP Report, Contract No 2: Permeability of Protective Coatings to Tritium (J.M. Braun)

CEA Report No 249 G 389: A Standard Fire Test Method for Grouped Cable (D.J. Stonkus)

CEA Report No 195 D 365: Removal and Destruction of PCB from Contaminated Soils and Associated Materials (W.J. Janis and J.S. Ferrie)